III. "An Instrument for grinding Section-plates and Prisms of Crystals of Artificial Preparations accurately in the desired directions."

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(Abstract.)

This instrument has been devised in order to replace by a method of precision the difficult, wearisome, and, at the best, only approximate current method of grinding by hand, upon a slightly convex plate of ground glass lubricated with oil or a solvent, the section-plates and prisms of the relatively soft and fragile crystals of artificial preparations which are required for the determination of the optical constants. It is possible by means of it to grind and polish a truly plane surface in any desired direction in a crystal accurately to within ten minutes of arc, an amount of possible error which would exercise no appreciable influence upon the values of the optical constants. This result may be achieved in a small fraction of the time hitherto required by the most successful hand-grinding, and, owing to the provision of a delicate arrangement for suitably modifying the pressure with which the crystal bears upon the grinding plane, with only the very slightest risk of fracturing even a friable crystal. An arrangement is, moreover, provided by which a second surface may be ground parallel, with a like degree of accuracy, to the first. The sections and prisms furnished by the instrument possess the further advantage of being so highly polished as to enable them to be employed directly without cemented cover-glasses for the determination of the optic axial angle and refractive indices, and the values of these constants derived from them are no longer only approximate but precise.

A short but relatively wide hollow cone, differing but slightly from a cylinder, is rigidly supported vertically above a heavy base by three stout pillars and a triangular cross-plate. Within it rest three movable inner axes. The first carries at its upper end a horizontal circle divided into half degrees, reading, with the aid of a vernier, to minutes, and provided with a fine adjustment; the axis and circle are capable of rotation by a milled ebonite disc carried at the lower extremity of the former. The bore of this axis is cylindrical, and within it the second axis is capable of vertical motion, rotation in the socket being prevented by a rib and groove. The weight of this second axis and all that it carries may be wholly or partially counterbalanced by a pair of levers whose fulcrum supports rest upon the

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circle-plate, whose power-arms are weighted, and whose short, curved arms terminate in blunt knife edges which press upwards against a collar fixed to the axis. The levers may be thrown out of action when desired, and the weight of the axis added to by placing small shot or weights in a brass cup carried at the upper end of the axis. This arrangement enables the weight above the crystal to be modified to any extent. Within the second axis slides without rotation the third one, which carries at its lower end the crystal and its means of adjustment. The upper portion of this axis is tapped with a fine screw thread, and the axis can be raised or lowered by a corresponding milled nut. A collimator and telescope, arranged in a horizontal plane at a suitable height for observing the crystal, are provided; they are movable over circular guiding arcs, whose centre lies in the vertical axis of the instrument. Just below the plane of the optical tubes the horizontal grinding disc is supported in a frictionless bearing carried by an adjustable tripod. It is capable of rotation by a suitable whirling apparatus arranged equally on each side of the axle so as to minimise the strain of the band. The disc is of moderately finely-ground, truly plane plate-glass, suitably mounted in a brass frame, and lies upon a second, from which it is readily detachable, so finely ground as to be almost transparent, and which is employed exclusively for giving a final polish to the surface ground by the removable disc. The grinding is under best control when the driving pulley, which is provided with a suitable handle, is rotated by hand, each revolution producing two revolutions of the grinding disc.

The means of adjusting the crystal so that any desired direction in it may be brought perpendicular to the grinding surface are afforded by two circular motions in the form of movable segments rotated by tangent screws, which, in addition to a pair of centering movements, are carried at the lower extremity of the inner vertical axis, and the common centre of which is occupied by the crystal. These circular movements are graduated to read directly to degrees, and easily by estimation to ten minutes. Two interchangeable pairs of them are provided; the planes of motion of one pair are fixed at right angles, while the planes of the other pair, designed for use in more complicated cases of symmetry, may be adjusted at any desired angle to each other by means of a small graduated horizontal circle carried by one of them.

The crystal is attached to the small cross-grooved disc of the crystal holder by a hard and rapidly-setting wax. It is adjusted so that the zone of faces perpendicular to which it is desired to grind a surface, if such a zone is developed, is parallel to the vertical axis. If such a zone is not present, as will happen in monoclinic and triclinic crystals, a prominent zone, whose position with respect to the principal directions of optical elasticity is known from goniometrical, stauroscopical, and convergent light observations, is first adjusted parallel to the axis and with one or two pairs of faces parallel to one or both of the planes of circular motion, and subsequently by movement of one or both of the segments over the calculated arc or arcs, the desired direction can be adjusted accurately perpendicular to the grinding disc. Provision for setting any face exactly parallel to a circular motion is provided in a special crystal holder which permits of the requisite amount of rotation after the holder is fixed in its socket. The grinding disc is lubricated with a mobile oil incapable of attacking the crystal, so that the reference faces may be preserved for checking the adjustment after grinding. The crystal is brought down near to the grinding disc by lowering the inner axis, and it is then lowered into contact with the disc and the pressure with which it bears during the grinding regulated by manipulation of the levers.

For grinding the parallel surface the crystal, mounted by its ground surface upon a very small glass disc, is enclosed in a receptacle for it in a special crystal holder consisting of two parts screwed together, the crystal downwards so as to pass through a central aperture in the lower portion in which the disc is supported by a very thin annulus. The broad under surface of the upper portion of the holder, against which the glass disc is pressed when the two parts are screwed together, is made truly plane, and can be adjusted accurately parallel to the grinding disc. The disc and crystal may be removed from time to time during the grinding without disturbing the adjustment, so that grinding may be stopped when the section exhibits small rings in its interference figure. Half an hour is ample for grinding and polishing the two surfaces, and it is unusual to break a crystal, provided the left hand is used to control the nearest lever, and thus ascertain by the delicate sense of touch how the crystal is supporting the strain, when the lever may be manipulated, almost involuntarily, accordingly.

Prisms are quite as readily ground and polished. It is possible in most cases to grind two surfaces symmetrically inclined to a plane of optical elasticity and with the edge of intersection parallel to an axis of optical elasticity, by suitable adjustment of the crystal with the aid of the movements provided and with reference to existing faces.